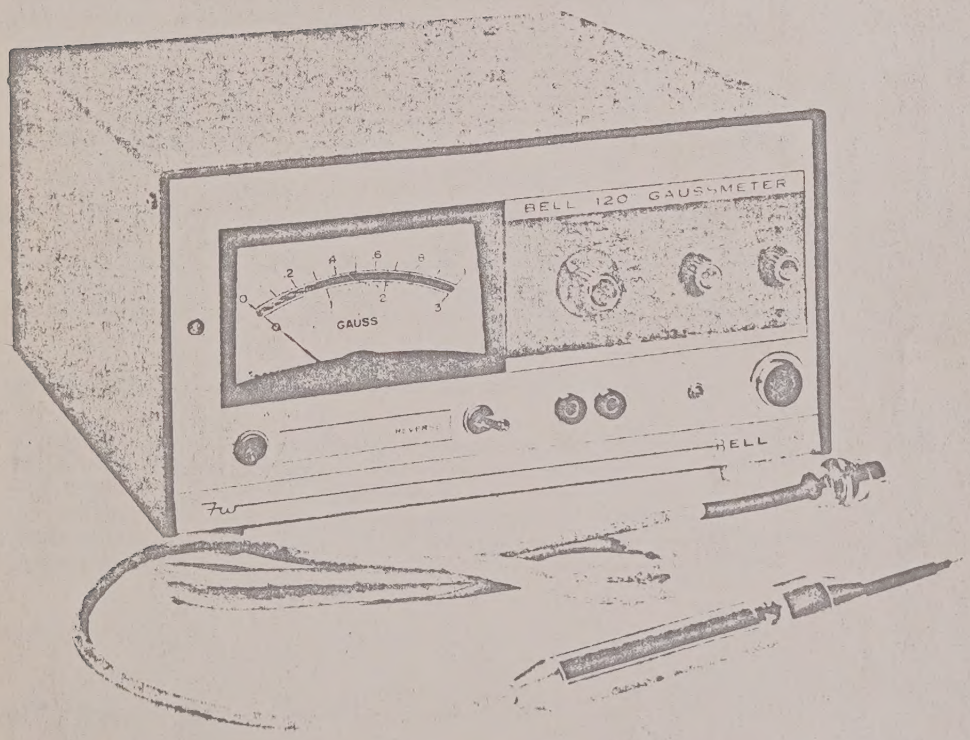
F.W.
BELL
MDL 120
GAUSSMETER

DAVE CAUZERO

OPERATING AND SERVICING MANUAL

MODEL 120
GAUSSMETER



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SECTION I

SPECIFICATIONS

MODEL 120 GAUSSMETER

GAUSS RANGE:

.01 gauss to 30,000 gauss in twelve ranges. Full scale readings in gauss of:

.1	3	100	3,000
.3	10	300	10,000
1.0	30	1000	30,000

ACCURACY:

$\pm$1% of full scale plus accuracy of reference magnet up to 10,000 gauss. Calibration curve available above 10,000 gauss. $\pm$2% of full scale up to 10,000 gauss when using built-in calibration feature. Accuracy at reference points depends on accuracy of reference magnets used; 0.5% or better available.

FREQUENCY RESPONSE:

Meter responds only to DC fields and is direction sensitive. AC fields up to 60 cps can be measured at the output jacks using oscilloscope or other external indicator. (See frequency response curve, Fig. III–2.) Up to 400 cps response can be provided on special order.

OUTPUT:

DC voltage proportional to meter reading; approximately 300 millivolts at full scale. Output impedance approximately 10,000 ohms. AC response as indicated above. Will drive most servo-type recorders directly.

POWER:

117/234 volts $\pm$ 10%, 50–60 cps, 40 watts.

DIMENSIONS:

6 5/8" high, 12 1/4" wide, 13 1/2" deep.

WEIGHT:

Net 15 lbs., shipping 20 lbs.

SECTION II

GENERAL DESCRIPTION

II–1 GENERAL

The Model 120 Gaussmeter is a precision magnetic flux measuring instrument which has been engineered to maintain long-term accuracy and stability. Simplicity of operation has not been sacrificed in spite of flexibility and extremely high sensitivity. Readings of 100 milligauss to 10,000 gauss full scale can be made with high accuracy, and up to 30,000 gauss with reduced accuracy. A wide variety of probe configurations can be interchanged with a simple re-calibration procedure. DC polarity is preserved so as not to lose direction information when tracing and plotting fields. AC fields up to 60 cps can be observed and measured, using an external indicator. Frequency response can be extended up to 400 cps on special order.

II–2 CONTROLS AND CONNECTORS

A. FRONT PANEL

ON

This toggle switch controls AC power to the instrument. With the switch on and proper power provided, the meter will be illuminated.

REVERSE

The REVERSE switch allows down-scale readings to be brought on scale without having to reverse probe position.

RANGE

This 12 position rotary switch selects proper range for field being measured.

ZERO

The controls marked COARSE and FINE are used for obtaining meter zero and for bucking out small fields such as the earth's magnetic field. A third control, the unmarked screwdriver slotted trimmer potentiometer located directly below the FINE control, is used for initial balancing when changing probes.

INPUT

The INPUT receptacle receives the probe cable plug. For proper operation the cable plug must be seated completely in the receptacle and the coupling ring must be tight.

OUTPUT

The OUTPUT jacks accept a double banana plug with standard 3/4 inch spacing. The left-hand jack (black) is at chassis potential. The voltage between the jacks is proportional to the meter reading and is not affected by the REVERSE switch. This voltage can be used to drive an external DC or AC instrument. A suitable DC meter can be connected for remote reading, or a recorder (servo type) can be used to make a permanent record. Source impedance is 10K ohms and open circuit voltage for full scale meter deflection is approximately 300 millivolts.

B. REAR PANEL

CAL

Lever switch S4 in the up position connects a standard calibrate voltage into the amplifier input for use in the self-calibrate procedure. This switch is spring loaded so that it always returns to the normal operating position when not in use. Potentiometer R52 is used to calibrate the amplifier gain, either when using the self-calibrate feature or reference magnets.

CONTROL CURRENT ADJUST

Lever switch S3 in the up position connects the meter to indicate control current through the sensing element. Potentiometer R9 is used to adjust control current reading to full scale deflection.

II–3 POWER

The power cable supplied has three conductors and is terminated in a three-prong plug recommended by the National Electrical Manufacturers' Association. The round pin is connected to the chassis and grounds the instrument when used with the appropriate receptacle. An adapter may be used for connection to a standard two-contact receptacle. The ground is brought out of the adapter by means of a short wire which should be connected to a suitable ground for protection of operating personnel.

The Model 120 is normally wired for operation from a 117 volt, 50–60 cps power source. To convert it for 234 volt 50–60 cps operation the dual primary of the power transformer is changed from parallel to series connection. Refer to the schematic diagram for details. When converting from 117 volt to 234 volt operation, replace the 1 ampere slow-blow fuse with a 1/2 ampere slow-blow fuse.

SECTION III

OPERATING INSTRUCTIONS

III–1 PROBE HANDLING

CAUTION

The sensing elements used with the Model 120 are extremely thin and fragile and can easily be permanently damaged. Special care should be exercised in handling the transverse probes, such as the YA–47, which allow exposure of the thin sensing element for measurements in narrow gaps. To expose the element, rotate the outer protective tube counter-clockwise (about 30 degrees). This releases the safety catch and allows the tube to be pushed back into the handle. Always restore the outer tube to the protective position when not actually making narrow gap measurements. The safety catch will automatically engage when the tube is pulled out to its extreme position and released. Axial probes, such as the YA–48, are not as fragile as the transverse probes and have no protective tube.

The sensing element used in all probes is strain sensitive and no forces should be applied directly against it during measurement. Also, it should be protected from temperature shock, such as touching against hot or cold objects. High temperature environments, rapid thermal changes, or high velocity air flow over the element can also result in apparent drift of the zero setting on the lower ranges and should be avoided.

No attempt should be made by the user to repair or modify the probe assembly in any way. The probe cable is of special design and its terminations in the cable plug and probe handle are very precisely adjusted to cancel out quadrature voltages which would cause overload and non-linear operation on the lower ranges.

If needed, probes with longer cables can be obtained on special order.

III–2 APPLYING POWER

Before turning the instrument on connect a probe to the input receptacle (attach securely) and turn the RANGE selector to the 30K position. Plug the power cable into a source of specified voltage and frequency.

Turn the power switch on and allow five minutes for preliminary warm-up. Complete stability is reached in about one hour.

III–3 PROBE BALANCE ADJUSTMENT

A. TRIMMER POTENTIOMETER ADJUSTMENT

If the instrument has not been previously adjusted for the particular probe installed, some adjustment of the probe-balance trimmer will probably be required. This is the small screwdriver slotted control directly below the FINE control. First set the COARSE control to approximately mid-range. Rotate the RANGE selector counter-clockwise until a reading is obtained on the meter (if down-scale reading occurs, throw REVERSE switch to opposite position). Adjust trimmer to reduce reading toward zero while continually reducing the range setting until near zero reading is obtained on the 30 gauss range. DO NOT ADJUST TRIMMER POTENTIOMETER ON LOWER RANGES.

B. ZERO ADJUSTMENT

The COARSE control will now have adequate range to provide adjustment to zero and about one gauss or more each side of zero. For precise zeroing on the lower ranges use the FINE control as needed.

The above zeroing procedure can be carried out quite rapidly without "banging" the meter pointer in the process. Although meter protection is designed into the circuitry, needless "banging" of the pointer can result in meter damage and should be avoided.

NOTE: Clock-wise rotation of the trimmer and ZERO controls results in up-scale meter deflection (REVERSE switch in normal position).

III–4 CALIBRATION PROCEDURE

When changing probes, it is necessary to repeat the probe balance adjustment procedure (Sec. III-3) and recalibrate the instrument for that particular probe. The instrument should be turned on, with probe connected, at least one hour before calibrating.

There are two steps involved in calibrating the Model 120:

A – Adjust control current
B – Adjust amplifier gain

A. ADJUST CONTROL CURRENT

After connecting and zeroing the probe, set the rear panel lever switch S3 in the CONTROL CURRENT ADJUST position. Loosen the lock nut on R9 (adjacent to S3) and adjust for exactly full scale deflection on meter. Tighten lock nut and restore S3 to normal position.

B. ADJUST AMPLIFIER GAIN

After adjusting the control current the amplifier gain must be adjusted in accordance with the sensitivity of the particular probe in use, using one of the following methods:

1. Calibration Against a Reference Magnet
2. Calibration Against Probe CAL Constant

For best accuracy, calibration using a reference magnet is recommended. Calibration against the probe CAL constant is a transfer method giving slightly reduced accuracy, but is somewhat easier to accomplish and often more convenient than using a reference magnet.

1. CALIBRATION AGAINST A REFERENCE MAGNET

If the reference magnet used is below 100 gauss the zero procedure must be accomplished with the probe inside a shielded chamber, such as the Bell YA-111 zero gauss chamber. Next, set the RANGE switch to proper position for the flux density rating of the reference magnet. Insert the probe in the magnet and position for maximum meter reading. Then adjust the CAL control, R52 on rear panel, to make the meter reading agree with the value of the reference magnet.

2. CALIBRATION AGAINST PROBE CAL CONSTANT

Each probe has been checked against calibrated magnets under standard test conditions and assigned a sensitivity constant. To transfer this value into the instrument, first set the RANGE switch to the 30K-CAL position. Next operate the CAL switch S4 on the rear panel and note the meter reading on the 0-1 scale. Adjust the CAL potentiometer R52 to make the meter read the value of the CAL CONSTANT indicated on the probe handle. Release S4 and the instrument is ready for use.

III-5 MAKING MEASUREMENTS

A. LOW LEVEL MEASUREMENTS

IMPORTANT

The Model 120 is an extremely sensitive instrument and its use on the lower ranges requires that certain precautions be observed.

The earth's magnetic field will give about half-scale meter reading on the 1 gauss range in the U.S.A. (depending on the position of the sensing element and the setting of the ZERO controls). This obviously can cause increasingly greater errors below the 100 gauss range as well as considerable overload of the instrument on the .3 and .1 gauss ranges. For this reason, the effects of the earth's field (and any other fields that may be present) must be eliminated to obtain satisfactory readings at low levels.

To obtain "absolute" or "true" zero requires adequate shielding of the probe. Shielding can be accomplished by the use of high-permeability material such as mu-metal. Several layers or nesting cans may be necessary, depending on the degree of shielding desired and the material used. The YA-111 ZERO GAUSS CHAMBER provides more than 80 db of attenuation in fields up to 300 gauss. This is more than adequate to reduce the earth's field below the sensitivity of the Model 120 GAUSSMETER.

For many low-level measurements it will not be necessary to obtain "absolute" zero but will be sufficient to reduce the effects of the earth's field and any other extraneous fields by one of the following methods:

1. Maintain the probe in a fixed relationship to extraneous fields and use the ZERO controls to "cancel out" their effect.

2. Orient the probe to a point midway between peak readings in each direction.

3. Use Helmholtz coils to generate a cancelling field.

For exploratory work at low flux densities it is usually satisfactory to mount the probe in a clamp, zero out extraneous fields, and then move the device under test in the vicinity of the sensing element.

B. MEASURING DC FIELDS

In measuring steady DC fields the probe is oriented in the field or gap to obtain the highest meter reading. For best accuracy always select the range which gives the highest meter deflection.

Transverse probes measure the component of flux density, B, which is normal to the plane of the sensing element. Axial probes measure the component of B which is parallel to the axis of the probe (see Fig. III-1). Careful positioning of

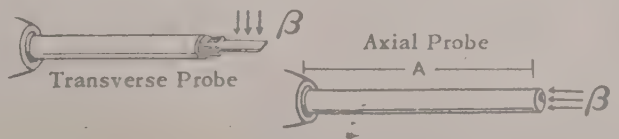
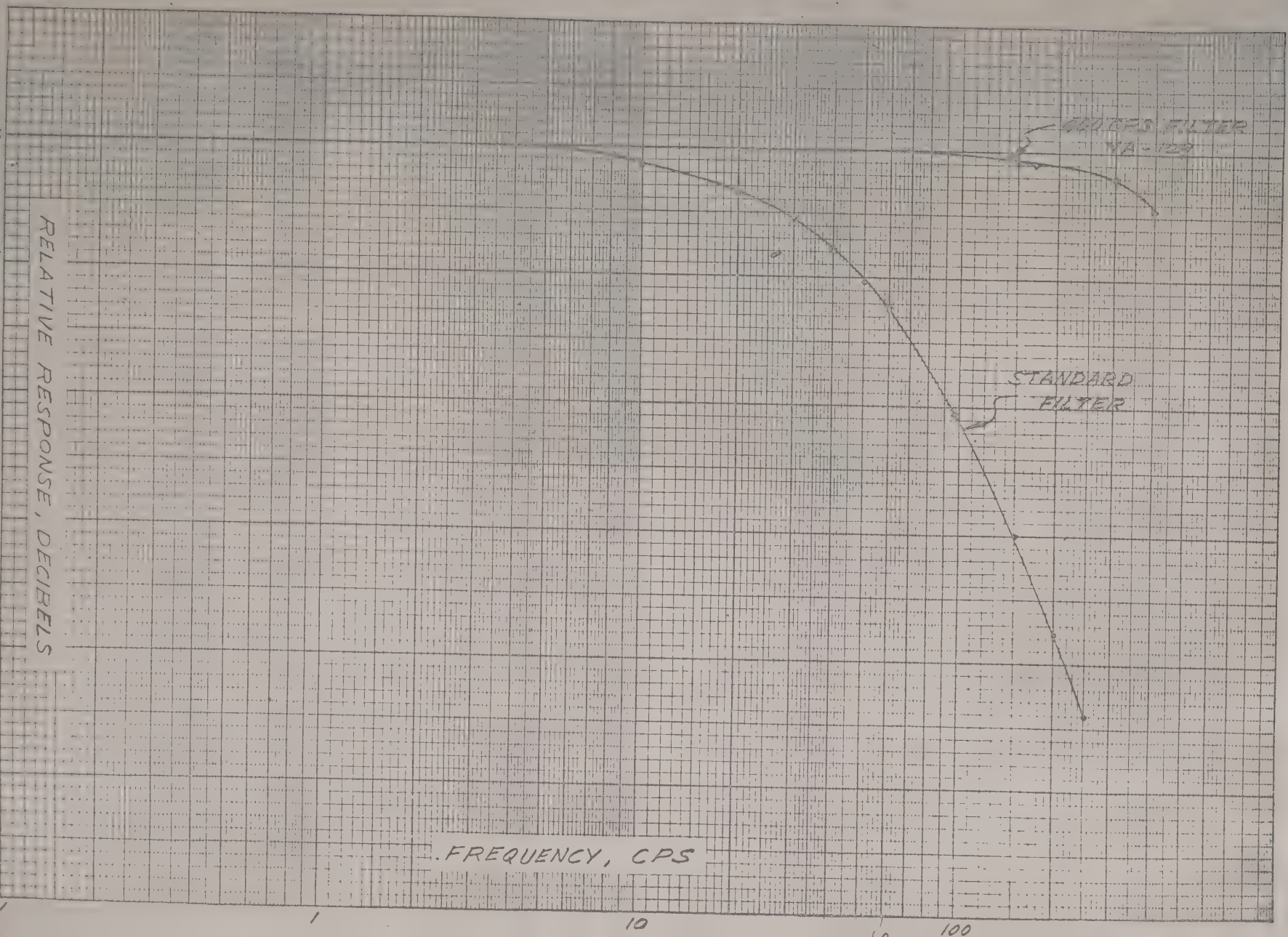


Fig. III-1


400 CPS FILTER
STANDARD FILTER
RELATIVE RESPONSE, DECIBELS
0
-5
-10
-15
-20
-25
.1
1
10
100
FREQUENCY, CPS

the probe relative to the flux lines is necessary in order to obtain the most accurate reading. If a down-scale reading is obtained, either throw the REVERSE switch on the Model 120 or reverse the position of the probe in the field.

Always observe the precautions outlined in paragraph III–1 to prevent probe damage and to minimize errors in making measurements.

C. MEASURING AC FIELDS

The Model 120 can be used to observe and measure AC fields by using a suitable external indicator connected to the output jacks. The frequency response depends on the internal filter used in the Model 120 (Refer to Fig. III–2). With the standard filter the response is down approximately 6 db. at 60 cps. On special order a 400 cps filter, Bell YA–129, is available which will permit use of the Model 120 up to 400 cps. This filter mounts in holes already provided inside the instrument.

An oscilloscope with DC response can be quickly calibrated to measure AC fields directly. An oscilloscope graticule with ten major vertical divisions is very helpful. The oscilloscope is calibrated as follows:

1. Connect the Model 120 output jacks to the oscilloscope vertical DC input.
2. Set the Model 120 RANGE switch on the 1 gauss range and adjust the ZERO controls to give zero meter reading.
3. Adjust the oscilloscope trace to the bottom graticule line.
4. Adjust the Model 120 ZERO controls to give full scale meter deflection and adjust oscilloscope gain to put trace at top graticule line.
5. Set rear panel switch S3 in the CONTROL CURRENT ADJUST position. This removes the meter from the output circuit to prevent it from influencing frequency response and from unnecessary vibration caused by low frequency signals.

When reading AC fields the steady field (DC) components should be minimized in order to avoid amplifier overload. This will be accomplished if the oscilloscope trace is kept in view by adjusting the Model 120 ZERO controls or by probe positioning, and NOT by adjusting oscilloscope positioning controls.

If desired, an AC VTVM can be used along with the oscilloscope. A recorder having suitable frequency response and sensitivity can be used in place of the oscilloscope, using the same method for calibration.

SECTION IV

THEORY OF OPERATION

IV–1 GENERAL

The operating principle of the Model 120 GAUSSMETER is quite similar to that of a DC chopper amplifier. The sensing element acts as the input chopper, providing an AC output voltage when placed in a DC magnetic field. The AC signal is amplified and then restored to DC by a synchronous demodulator. The DC output voltage drives the panel meter and is available at the OUTPUT jacks for operation of auxiliary instruments.

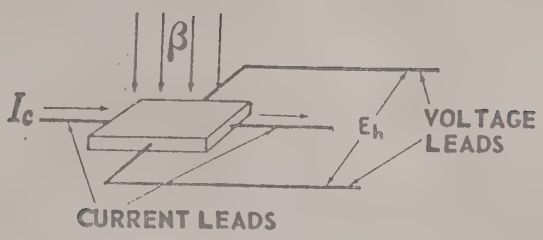


Fig. IV–1 Sensing Element

IV–2 SENSING ELEMENT

The sensing element is a semiconductor device operating on the Hall Effect principle. It consists of a thin rectangular wafer of high-purity indium arsenide with 4 leads attached (see Fig. IV–1).

The control current, I_c, passes through the long dimension of the element. When placed in a magnetic field some of the charge carriers are deflected across the crystal resulting in the Hall voltage, E_h, appearing across the voltage leads. This voltage is directly proportional to the control current and the magnitude of magnetic flux vector which is at right angles to the face of the crystal.

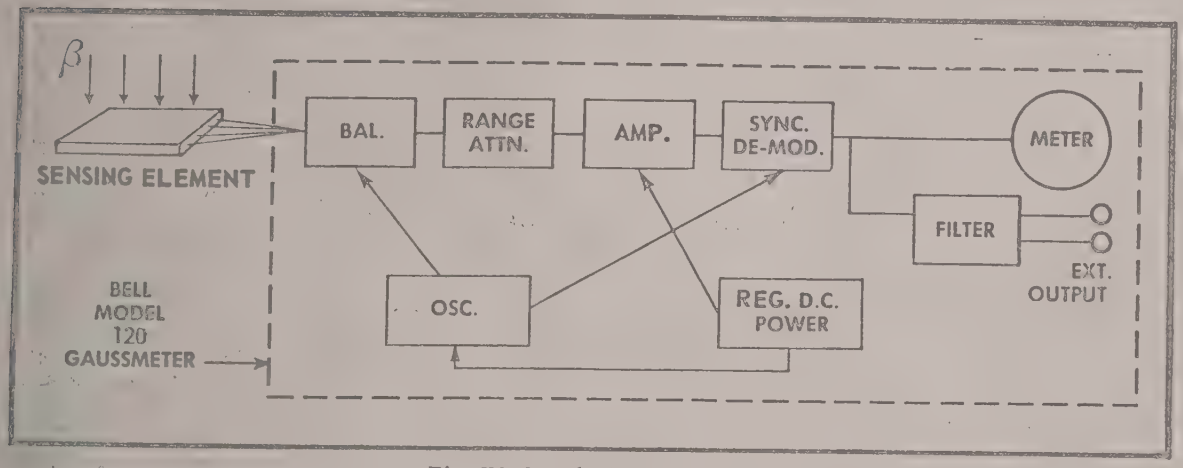


Fig. IV–2 Block Diagram

IV–3 CIRCUIT OPERATION

A. INPUT – ATTENUATOR SECTION

Refer to the simplified block diagram, Fig. IV–2.

The 100 ma. constant control current is supplied to the sensing element by the 1.1 KC oscillator. With no field present, the balance network reduces the residual output of the sensing element to zero. In the presence of a DC field the sensing element produces a 1.1 KC signal. An AC field produces a signal composed of sidebands on either side of 1.1 KC.

The signal voltage is applied through an input transformer to the RANGE attenuator, which consists of precision voltage dividers in the grid and cathode circuits of cathode follower VI.

B. AMPLIFIER – DEMODULATOR SECTION

The amplifier section consists of four R–C coupled stages, two pentodes and two triodes. The second triode is a cathode follower output stage.

The synchronous demodulator is connected between the amplifier output and ground. On every other half cycle of the oscillator the demodulator diodes conduct and short circuit the amplifier output to ground. On alternate half cycles the diodes are cut off and the amplifier output feeds

directly to the meter and low pass filter. If a signal is present it is rectified by the synchronous demodulator action and the DC component actuates the meter. The low pass filter removes the 1.1 KC carrier and allows the DC component plus low frequency side bands (see III-5-C) to appear at the OUTPUT jacks.

C. OSCILLATOR SECTION

A push-pull oscillator is used for low distortion and good amplitude stability. The buffer-amplifier stage is also push-pull and is transformer coupled to the control current circuit and to the synchronous demodulator.

D. POWER SUPPLY

Current for the high-voltage supply is rectified by silicon rectifiers CR-1 through CR-4 and regulated by series regulator tube V7. Amplified control voltage is supplied to the grid of V7 by V8. The cathode voltage of V8 is held constant by the voltage reference tube, V9.

SECTION V

MAINTENANCE

V–1 INTRODUCTION

This section contains the necessary instructions and diagrams for maintaining the Model 120. In addition to the schematic diagram, a block diagram giving typical signal-voltage levels is provided for rapid trouble shooting.

Repair and adjustment of the instrument should be attempted in the field only where adequate test equipment and qualified personnel are available. Refer to the warranty page for the procedure to be followed should factory repair service be required.

V–2 REQUIRED TEST EQUIPMENT

The following test equipment is required to test and adjust the Model 120 Gaussmeter:

1. A high-impedance DC voltmeter such as Hewlett-Packard Model 410B or 412A.
2. A high-impedance AC voltmeter such as Hewlett-Packard Model 400D or 400H.
3. Any good oscilloscope having a response to DC.
4. An adjustable line voltage source, accurately metered.

V–3 COVER REMOVAL

CAUTION

Always disconnect power cable from power line when removing or replacing the top cover.

First remove the top cover, then the bottom plate. The top cover is held in place by eight screws. After removing the screws slide the cover forward until the clips inside the top rear strike against the front panel. Then raise the front of the cover until the cover flanges are free of the front panel. The cover will then lift off. It is easily replaced by the reverse procedure. The bottom plate is secured by six screws, three along the front and three along the rear.

V–4 PERFORMANCE TEST

This test can be performed in a few minutes without removing the cover and bottom plate. While this test is not conclusive, it is a good indication of satisfactory performance.

A – TEST CONDITIONS

1. Set RANGE switch to the 30K–CAL range.
2. Connect a probe to INPUT.
3. Adjust supply voltage to 117 volts and allow instrument to warm up at least one hour.

B – OSCILLATOR TEST

1. Set the rear panel lever switch S3 in the CONTROL CURRENT ADJUST position.
2. Meter should indicate exactly 1.0 on upper scale. If necessary, adjust R9.
3. Reduce supply voltage to 105 volts and after a few minutes increase to 130 volts. The meter reading should not vary more than 0.5% from the reference.
4. Restore S3 to normal position and supply voltage to 117 volts.

C – AMPLIFIER TEST

1. Set the rear panel lever switch S4 in the CAL position. (A suitable wooden block to hold the spring-loaded switch in position will be helpful for this test.)
2. Rotate CAL control R52 over its entire range. The meter reading should smoothly change from 0.3 or below to full scale or above. Adjust for exactly full scale deflection.
3. Reduce supply voltage to 105 volts and after a few minutes increase to 130 volts. The meter reading should not vary more than 1% from the reference. Restore supply voltage to 117 volts.
4. Connect DC meter (see V–2) to OUTPUT jacks. DC output voltage should be approximately 300 millivolts.
5. Connect AC meter (see V–2) to OUTPUT jacks. AC output voltage should be less than 5 millivolts.

V–5 ADJUSTMENTS

Before making any adjustments the instrument should be operated for at least one hour with the covers in place.

A – REGULATED POWER SUPPLY

The B+ voltage at the output of the regulated power supply should be 220 volts, $\pm$ 3 volts. Set the supply voltage to 117 volts and measure

the B+ voltage between the chassis and the cathode of V7 series regulator tube. If necessary, adjust R7 (refer to Fig. V–1) to give correct B+ voltage.

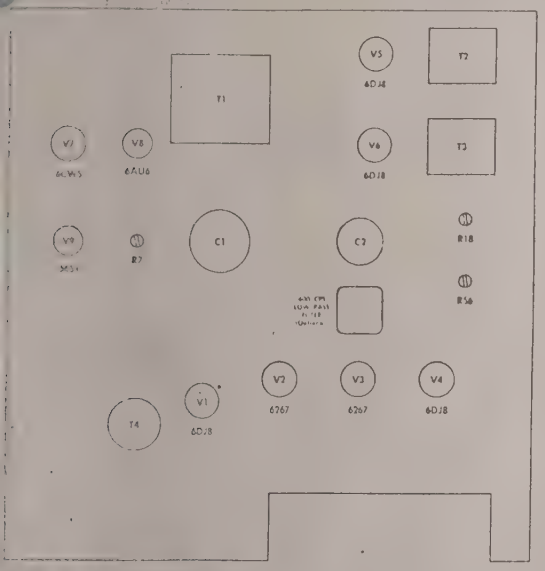


Fig. V–1 Chassis Layout Diagram (bottom view)

Vary the supply voltage from 105 to 130 volts. The B+ voltage should not change more than one volt.

B – METER ZERO ADJUSTMENT

Turn instrument off and allow two minutes for capacitors to discharge. Read meter (eliminate parallax by lining up pointer with its image in mirror). If pointer does not indicate exactly zero, make necessary adjustment by turning screw on meter face.

C – SYNCHRONOUS DEMODULATOR BALANCE

Perform the probe balance adjustment as described in III–3 then set the RANGE switch in the 30K position. The meter reading should be exactly zero and should not change more than ¼% of full scale when the REVERSE switch is operated. If an unbalance is noted remove V4 and repeat the above test. If this clears the trouble a leaky coupling capacitor, C26, is probably at fault. If no improvement is noted adjustment of the demodulator balance control, R56, will be necessary.

To adjust R56 remove the bottom plate, leaving the top cover in place. Slide the left side of the instrument over the edge of the work bench just far enough to make R56 accessible (see Fig. V–1). Adjust R56 while flipping the REVERSE switch from one position to the other until the change in meter reading disappears.

at 100 millivolts, 1100 cps. Connect a pair of twisted leads across R16, the 1 ohm, ½% resistor located on the terminal strip near the left rear corner of the chassis. Run the leads out through one of the vent slots in the rear panel and connect to the AC voltmeter. Replace the top cover, connect a probe to the INPUT receptacle, and allow instrument to run for an hour or longer.

Adjust R9 on the rear panel for exactly 100 millivolts on the AC meter. Now put the CONTROL CURRENT ADJUST switch, S3, in the "up" position. The Model 120 meter should indicate exactly full scale. If not, adjust R18 as necessary. Access to R18 should be attained similarly as described for R56 in V–C. Return S3 to the "down" position and check to see that the AC meter still indicates 100 millivolts.

E – HUM BALANCE ADJUSTMENT

The hum balance potentiometer, R21, is located on the top side of the chassis near the V1 socket. It may require slight adjustment when changing V1 or V2. With a probe connected to the instrument rotate the RANGE switch to the 1K position. Connect an oscilloscope to the OUTPUT jacks to observe hum. Adjust R21 for minimum hum level. Be sure the Model 120 chassis is grounded during this adjustment.

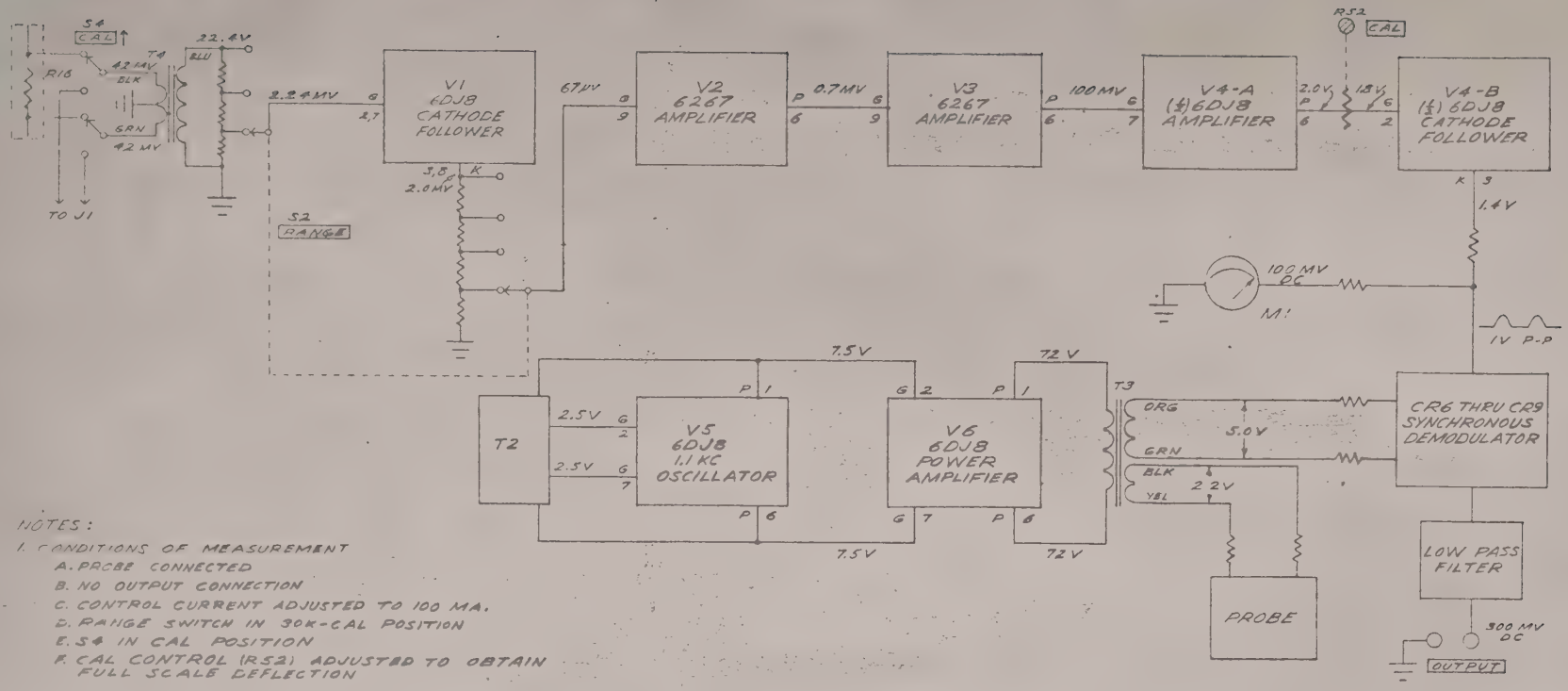
F – AMPLIFIER PHASE ADJUSTMENT

The amplifier phase control is the trimmer capacitor, C19, mounted on the terminal strip adjacent to the V3 socket. It may require slight adjustment when replacing V3 or associated circuit components.

To adjust the amplifier phase control set up the test conditions as outlined in V–4A. Remove top cover and connect an oscilloscope between chassis and the synchronous demodulator (negative lead of C26 - refer to schematic diagram). Set the rear panel lever switch S4 in the CAL position and observe wave form on oscilloscope. The wave form should be a half-wave rectified sine wave as indicated on the Signal Level Block Diagram, Fig. V–2. If any phase shift is observed, correct by adjusting C19 with an insulated screwdriver.

V–6 TROUBLE SHOOTING

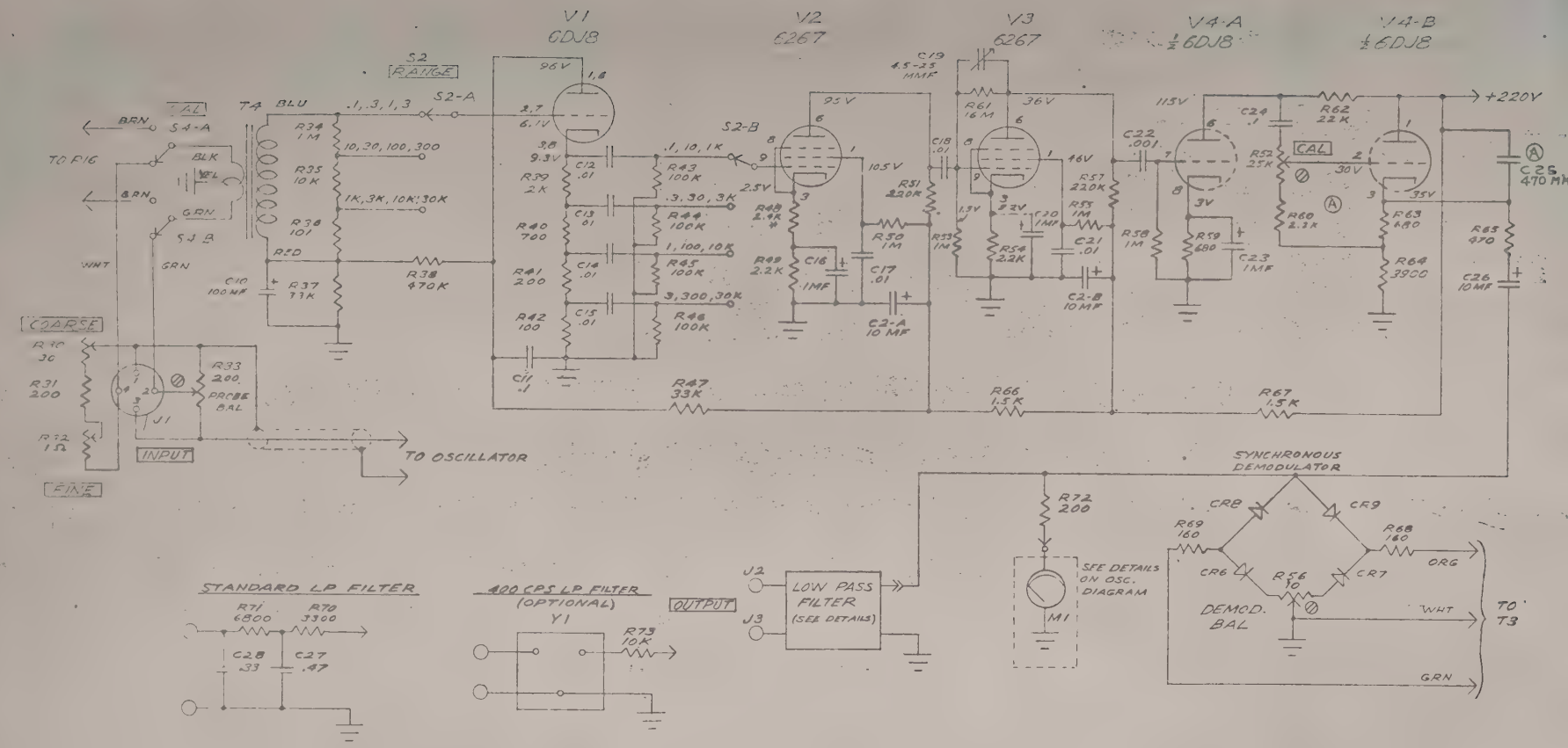
The Signal Level Block Diagram, Fig. V–2, gives typical signal voltages throughout the instrument under specified test conditions. Its use should facilitate rapid trouble localization. The Schematic Diagrams, Figs. V–3 and V–4 give typical DC voltages to aid in finding the defective component after the trouble has been localized.



NOTES:

1. CONDITIONS OF MEASUREMENT
   - A. PROBE CONNECTED
   - B. NO OUTPUT CONNECTION
   - C. CONTROL CURRENT ADJUSTED TO 100 MA.
   - D. RANGE SWITCH IN 30K-CAL POSITION
   - E. S4 IN CAL POSITION
   - F. CAL CONTROL (RS2) ADJUSTED TO OBTAIN FULL SCALE DEFLECTION
2. LETTERS AND NUMBERS OUTSIDE TUBE BLOCKS INDICATE TUBE ELEMENT AND SOCKET PIN
3. ALL VOLTAGES ARE RMS 1100 CPS AND MEASURED WITH RESPECT TO GROUND, UNLESS OTHERWISE INDICATED
4. AC VOLTAGES MEASURED WITH HIGH IMPEDANCE METER SUCH AS HEWLETT-PACKARD MODEL 400 D

Fig. V–2 Signal Level Block Diagram



NOTES

1. * DENOTES AVERAGE VALUE. PART ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE.
2. CONDITIONS OF VOLTAGE MEASUREMENT:
   A. LINE VOLTAGE AT 117/230 VOLTS 50/60 CPS
   B. RANGE SWITCH IN 30K POSITION
   C. PROBE CONNECTED
   D. DC VOLTAGES MEASURED WITH RESPECT TO CHASSIS USING VTVM
   E. AC VOLTAGES MEASURED BETWEEN POINTS INDICATED USING 1000 OHMS/VOLT OR HIGHER AC METER
3. ALL CAPACITANCE IN MFD, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED
   1K = 1 THOUSAND, 1M = 1 MILLION
4. COVERS SERIAL NO. 20151 AND ABOVE

Fig. V–3 Amplifier-Demodulator Schematic Diagram

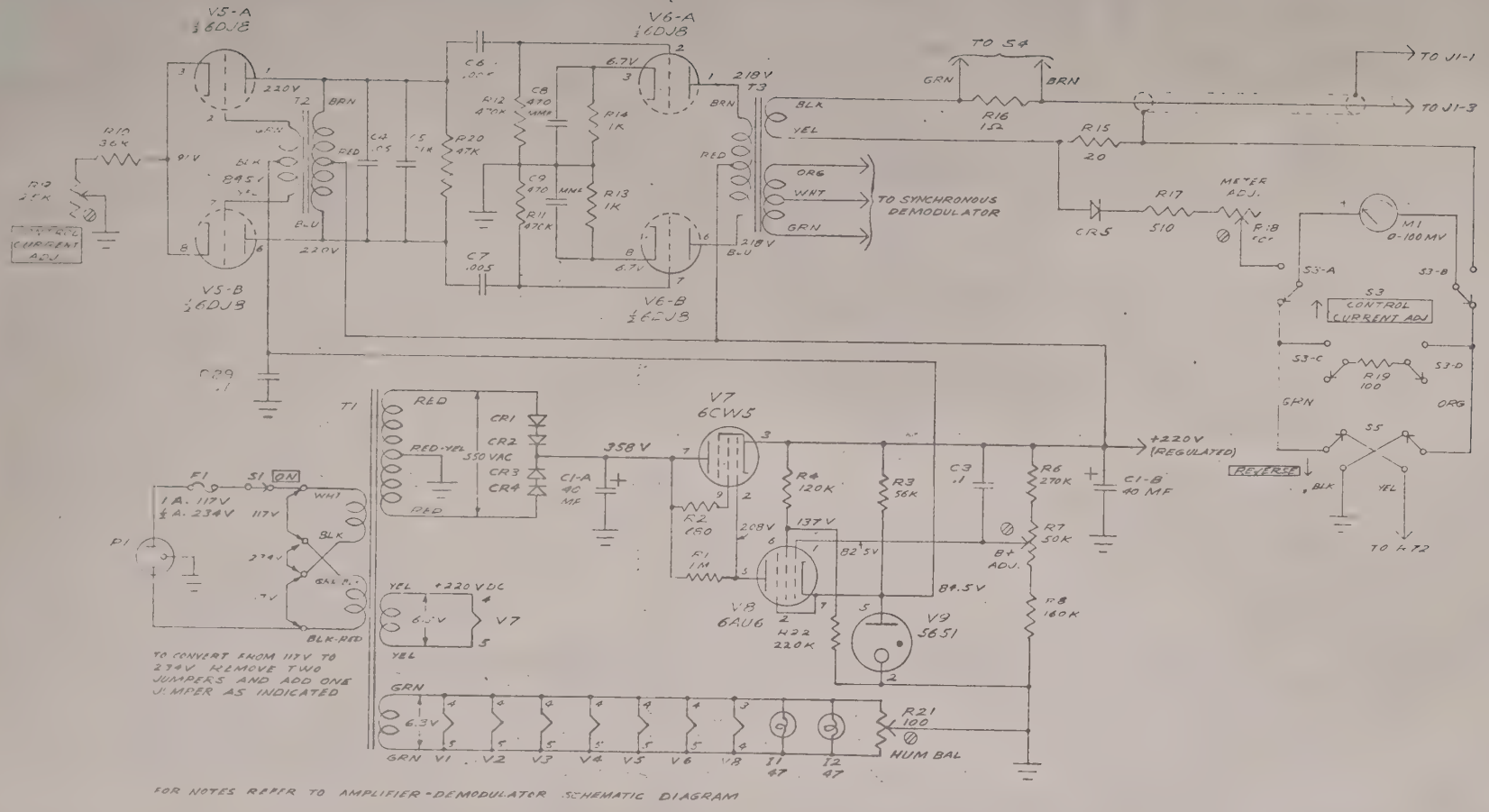


Fig. V–4 Oscillator - Power Supply Schematic Diagram

SECTION VI

PARTS LIST

Schematic Reference	Description	Bell Part No.
C1	Capacitor, electrolytic, 40–40 mfd, 450 VDCW	
C2	Capacitor, electrolytic, 10–10 mfd, 300 VDCW	
C3	Capacitor, mylar, 0.1 mfd ± 10%, 600 VDCW	
C4	Capacitor, mylar, 0.05 mfd ± 10%, 600 VDCW	
C5	Capacitor, mylar, 0.01 mfd ± 10%, 600 VDCW See note 1 on schematic diagram	
C6,7	Capacitor, mylar, 0.005 mfd ± 10%, 600 VDCW	
C8,9	Capacitor, ceramic, 470 mmf ± 10%, 1000 VDCW	
C10	Capacitor, electrolytic, 100 mfd, 15 VDCW	
C11	Same as C3	
C12 thru C15	Capacitor, mylar, 0.01 mfd ± 10%, 150 VDCW	
C16	Capacitor, electrolytic, 1 mfd, 25 VDCW	
C17,18	Capacitor, mylar, 0.01 mfd ± 10%, 600 VDCW	
C19	Capacitor, variable, ceramic, 4.5 to 25 mmf. NPO, 600 VDCW	
C20	Same as C16	
C21	Same as C17	
C22	Capacitor, mylar, 0.001 mfd ± 10%, 600 VDCW	
C23	Same as C16	
C24	Same as C3	
C25	Same as C8	
C26	Capacitor, electrolytic, 10 mfd, 100 VDCW	

Schematic Reference	Description	Bell Part No.
C27	Capacitor, mylar, 0.47 mfd, ± 10%, 150 VDCW	
C28	Capacitor, mylar, 0.33 mfd, ± 10%, 150 VDCW	
C29	Same as C3	
CR1 thru CR4	Rectifier, silicon 500 PIV.	1N1491
CR5 thru CR9	Diode, germanium	Sylvania 1N270
	Diode assembly	YA369
F1	Fuse, 1 amp "slo-blo" (117 V operation) or	MDL 1
	Fuse, ½ amp "slo-blo" (234 V operation)	MDL ½
I1,2	Lamp, 6.3V, 150 ma, Type 47	
M1	Meter	MB117
P1	Power Cable, Type SV–18/3	WA088
R1	Resistor, composition, 1 megohm ± 10%, 1/2W	
R2	Resistor, composition, 680 ohms ± 10%, 1W	
R3	Resistor, composition, 56,000 ohms ± 10%, 1W	
R4	Resistor, composition, 120,000 ohms ± 10%, 1/2W	
R5	Not assigned	
R6	Resistor, composition, 270,000 ohms ± 5%, 1/2W	
R7	Resistor, variable, composition, 50,000 ohms, linear taper	RA116
R8	Resistor, composition, 160,000 ohms ± 5%, 1/2W	
R9	Resistor, variable, wirewound 25,000 ohms, linear taper	RA114
R10	Resistor, composition, 36,000 ohms ± 10%, 1/2W	
R11,12	Resistor, composition, 470,000 ohms ± 10%, 1/2W	

Schematic Reference	Description	Bell Part No.
R13,14	Resistor, composition, 1000 ohms ± 5%, 1/2W	
R15	Resistor, wirewound, 20 ohms ± 5%, 3W	
R16	Resistor, wirewound, 1 ohm ± 1/2%, 1W	
R17	Resistor, wirewound, 510 ohms ± 5%, 1W	
R18	Resistor, variable, wirewound, 500 ohms, linear taper	RA113
R19	Resistor, composition, 100 ohms ± 5%, 1/2W	
R20	Resistor, composition, 47,000 ohms ± 10%, 1/2W	
R21	Resistor, variable, wirewound, 100 ohms, linear taper	RA065
R22	Resistor, composition, 220,000 ohms ± 10%, 1/2W	
R23 thru R29	Not assigned	
R30	Resistor, variable, wirewound, 30 ohms, linear taper	RA042
R31	Resistor, wirewound, 200 ohms ± 5%, 1W	
R32	Resistor, variable, wirewound, 1 ohm, linear taper	RA041
R33	Resistor, variable, wirewound, 200 ohms, linear taper	RA135
R34	Resistor, deposited carbon, 1 megohm ± 1/2%, 1/2W	
R35	Resistor, deposited carbon, 10,000 ohms ± 1/2%, 1/2W	
R36	Resistor, deposited carbon, 101 ohms ± 1/2%, 1/2W	
R37	Same as R10	
R38	Same as R11	
R39	Resistor, deposited carbon, 2000 ohms ± 1/2%, 1/2W	

Schematic Reference	Description	Bell Part No.
R40	Resistor, deposited carbon, 700 ohms ± 1/2%, 1/2W	
R41	Resistor, deposited carbon, 200 ohms ± 1/2%, 1/2W	
R42	Resistor, deposited carbon, 100 ohms ± 1/2%, 1/2W	
R43 thru R46	Resistor, composition, 100,000 ohms ± 10%, 1/2W	
R47	Resistor, composition, 33,000 ohms ± 10%, 1W	
R48	Resistor, deposited carbon, 2400 ohms ± 5%, 1/2W See note 1 on schematic diagram	
R49	Resistor, composition, 2200 ohms ± 10%, 1/2W	
R50	Same as R1	
R51	Same as R22	
R52	Resistor, variable, composition, 25,000 ohms, linear taper	RA115
R53	Same as R1	
R54	Same as R49	
R55	Same as R1	
R56	Resistor, variable, wirewound, 10 ohms, linear taper	RA112
R57	Same as R22	
R58	Same as R1	
R59	Resistor, composition, 680 ohms ± 10%, 1/2W	
R60	Same as R49	
R61	Resistor, composition, 16 megohms ± 5%, 1/2W	
R62	Resistor, composition, 22,000 ohms ± 10%, 1W	
R63	Same as R59	
R64	Resistor, composition, 3900 ohms ± 10%, 1W	

Schematic Reference	Description	Bell Part No.
R65	Resistor, composition, 470 ohms ± 10%, 1/2W	
R66,67	Resistor, composition, 1500 ohms ± 10%, 1/2W	
R68,69	Resistor, composition, 160 ohms ± 5%, 1/2W	
R70	Resistor, composition, 3300 ohms ± 5%, 1/2W	
R71	Resistor, composition, 6800 ohms ± 5%, 1/2W	
R72	Resistor, composition, 200 ohms ± 5%, 1/2W	
R73	Resistor, composition, 10,000 ohms ± 10%, 1/2W Used only with optional 400 cps filter, Y1	
S1	Switch, toggle, SPST, 250 V, 3 amp	
S2	Switch, rotary, 12 pos,	SB034
S3	Switch, lever, 2 pos.	SA107
S4	Switch, lever, 2 pos., spring return	SA099
S5	Switch, toggle, DPDT 250 V, 3 amp	
T1	Transformer, power	LB035
T2	Transformer, oscillator	LA054
T3	Transformer, output	LA036
T4	Transformer, input	LA037
V1	Vacuum Tube, 6DJ8	
V2,3	Vacuum Tube, 6267	
V4,5,6	Same as V1	
V7	Vacuum Tube, 6CW5	
V8	Vacuum Tube, 6AU6	
V9	Vacuum Tube, 5651	
Y1	Filter Assembly, 400 cps Low Pass (Optional)	YA129

Schematic Reference	Description	Bell Part No.
	MISCELLANEOUS	
J2	Banana Jack, Red	G.C. 7817
J3	Banana Jack, Black	G.C. 7818
	Knob, range switch	KA075
	Knob, ZERO controls	KA076
	Fuseholder	HKP

SECTION VII

WARRANTY

F. W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof (excluding electron tubes, batteries, transistors and probe sensing elements, which parts are covered by a standard EIA 90-day warranty). This warranty covers instruments which, within one year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F. W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F. W. BELL, INC., and F. W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F. W. BELL, INC. instruments.

DAMAGE IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

All shipments of F. W. BELL, INC. instruments should be made via Railway Express or Motor Freight. Always use the original shipping carton and inserts, if possible, or pack the instrument in a sturdy container and surround the entire instrument with two or three inches of excelsior or similar shock-absorbing material.

F. W. BELL, INC.

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